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RUGGEDIZED FORENSIC LIGHT SOURCE

- 1 CROSS REFERENCE TO RELATED APPLICATIONS
- 2 This application claims the priority of U.S. provisional patent application no.
- 3 60/259,192 filed December 28, 2000, the disclosure of which is hereby incorporated
- 4 herein by reference thereto.
- 5

TECHNICAL FIELD

The present invention relates to light sources useful for illuminating and thus detecting the presence of forensic materials at a crime scene using light of wavelengths selected to enhance the likelihood of detecting such materials.

REFERENCE TO GOVERNMENT FUNDING

Not Applicable.

BACKGROUND OF THE INVENTION

Description of Related Art

Recent advances in DNA testing have rendered the gathering of forensic materials of increasing importance. However, even before the advent of DNA testing, the detection of forensic materials such as blood, perspiration, bone, skin, and the like has always been of great importance to crime fighters. For example, bone fragments that can be matched to a corpse would show that the individual who had suffered the crime may have been at a particular location. Fingerprints would identify individuals because of their unique characteristic. Loose hairs on a victims clothes could identify a possible assailant.

But as important as forensic evidence was in the past, it was only one of numerous circumstantial and objective sources of evidence which were weighed by juries and judges in their search for the truth and implementation of criminal justice objectives aimed at punishing and/or preventing criminal activities.

However, with the advent of DNA Testing, forensic material begins to approach, more closely than ever, a determination with certainty respecting certain types of criminal activity and particularly reliable circumstantial evidence with respect to

1 other types of criminal activity. For example, in rape cases, identification of seminal
2 fluids substantially amounts to a basis to convict or a basis to acquit. This is
3 especially the case where only the victims and the accused have their DNA patterns
4 in the sample.

5
6 Accordingly, the detection of forensic materials at a crime scene is of the utmost
7 importance whether to make an almost positive connection between a criminal and
8 a crime scene or to exonerate innocent people. One of the primary tools in detecting
9 forensic materials is the use of light having particular wavelength characteristics.
10 More particularly, a light that is produced by various types of forensic light sources
11 which include means to direct the light onto various parts of a crime scene. One
12 typical device, for example, comprises a light source and a six foot long fiber optic
13 member which directs light from the light source to a point in which the end of the
14 fiber optic member is pointed. A wheel containing a number of filters is mounted at
15 the end of the fiber optic light pipe. In order to select various wavelengths, the
16 wheel is rotated thus interposing different filters in front of the output of the light
17 pipe. The result is that the filters filter the light as it comes out of the light pipe and
18 allow only the light of a particular wavelength to fall on an object or area to be
19 illuminated. Such devices are relatively heavy and the long fiber optic light pipe is
20 of particular advantage because it allows the light source to be put down on the
21 floor and the light direction and source to be manipulated to the manipulation of the
22 very light and easy to manipulate fiber optic bundle light type. This is what
23 represents one of the easiest to use instruments and, a particularly effective
24 embodiment of a forensic light source. However, the bundles necessary for such a
25 device are relatively expensive and the use of a plurality of filters results in a
26 particularly large expense. Moreover, the fiber optic bundle is also a relatively
27 expensive item and contributes significantly to the cost. In addition, losses occur
28 during transmission along the fiber optic bundle and, accordingly, light sources of

1 especially high strength are needed to provide sufficient illumination energy at the
2 output of the light bundle and filters.

3

4 However, such systems are relatively expensive to manufacture. In addition, the
5 filter assembly is at the end of a relatively fragile fiber optic bundle and both the
6 filter assembly and fiber optic bundle are subject to abuse and shock, and need to be
7 protected.

8

9 Other approaches suffer from even greater problems. For example, in one system,
10 an array of filters located in a housing which contains the light source are operated
11 by remote control using an electrical switch located at the end of the light pipe
12 opposite the light source and filters. The result is the need for an electrical
13 connection and electrical control circuitry for activating additional motor systems
14 needed to move the filters. This has the result of decreasing reliability and system
15 life, while at the same time increasing the cost of the system.

16

17

SUMMARY OF THE INVENTION

18 In accordance with the present invention, a forensic light source is provided which
19 combines the easy maneuverability of a simple fiber optic bundle without the use of
20 a fiber optic bundle while at the same time preserving the flexibility of control with
21 the same hand that is moving the light source. In addition, the relatively light
22 weight nature of the system which is encountered by the hand used to scan the
23 crime scene is also maintained. Moreover, the same is achieved without the high
24 cost of an electrical control circuitry to control placement of filters as source. In
25 addition, these objects are achieved in a format which is particularly resistant to
26 shock and abuse. Finally, all the above advantages and objects of the invention are
27 achieved in a configuration which allows low cost and also provides for
28 compounding filtering characteristics to achieve versatility in the operation of the

1 system.

2

3 In accordance with the present invention, these objectives are achieved in the
 4 context of a system which comprises a light source contained within a housing. The
 5 housing includes a handle attached to the housing which allows the housing to be
 6 grasped by a user. Light is output from the housing through a filter wheel mounted
 7 on the housing. The filter wheel is positioned to allow for filter adjustment using the
 8 thumb of the hand which is grasping the housing while the other four fingers
 9 engage the handle to hold the housing in position. The same is achieved by having
 10 the filter wheels mounted in front of the output of the light source within the
 11 housing which is grasped by the hand. At the same time, power to the system is
 12 supplied not by an internal battery pack or internal power supply incorporating a
 13 transformer. Rather, a power supply or battery pack is coupled by a cable to the
 14 housing containing the light source. During use, the power supply is placed on the
 15 floor and the light source, relatively light because of the absence of the power
 16 supply components, is manipulated to direct light wherever one wishes to direct
 17 light. Likewise, when a battery pack is used, the battery pack is also coupled by a
 18 long wire to the housing of the inventive forensic light source. The result is that the
 19 weight of the battery pack is also kept off the hand doing the work of directing the
 20 light source in various directions.

21

22 BRIEF DESCRIPTION OF THE DRAWINGS

23 The advantages, and the system and apparatus of the present invention will be
 24 understood from the following description taken together with the drawings, in
 25 which:

26 Figure 1 is a front view taken from above of an embodiment of a forensic
 27 instrument constructed in accordance with the present
 28 invention;

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- 1 Figure 2 is a side view of the embodiment of the present invention in'
- 2 Figure 1 illustrating a preferred grip position during use of the
- 3 inventive instrument;
- 4 Figure 3 is a side view of the embodiment of the present invention in
- 5 Figure 1;
- 6 Figure 4 is a rear view of the embodiment of the present invention in
- 7 Figure 1;
- 8 Figure 5 is a front view of one of the filter wheels useful with the
- 9 embodiment of the present invention in Figure 1;
- 10 Figure 6 is a front view taken from above with the front cap piece of the
- 11 embodiment of the present invention in Figure 1 removed;
- 12 Figure 7 is an interior view of the front cap piece of the embodiment of
- 13 the present invention in Figure 1;
- 14 Figure 8 illustrates a mechanism for retaining the filter wheel in position;
- 15 Figure 9 illustrates a mechanism in Figure 8 engaging the filter wheel;
- 16 Figure 10 is a side view of an embodiment of the present invention
- 17 further illustrating the connection of the light source with a
- 18 battery pack;
- 19 Figure 11 is a side view of an embodiment of the present invention further
- 20 illustrating the connection of the light source with a power
- 21 supply;
- 22 Figure 12a illustrates a focusing position for the light output focusing lens
- 23 mounted in a turret which is slidably mounted to a tubular
- 24 member of the front cap.
- 25 Figure 12b illustrates a second focusing position for the light output
- 26 focusing lens, similar to that illustrated in Figure 12a mounted
- 27 in a turret which is slidably mounted to a tubular member of the
- 28 front cap.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Figure 1, the inventive forensic light source 10 is illustrated. Forensic light source 10 includes a housing 12 which may be grasped by the user using a handle 14. More particularly, as illustrated in Figure 2, the user uses a unit by grasping handle 14 with his hand 16. The unit is controlled by a pair of frequency selector dials 18 and 20 (Figure 1). The user positions his hand 16 in such a manner that thumb 22 on hand 16 may be placed over dials 18 and 20 and the thumb may be selectively used to rotate either dial 18 or dial 20 to a desired position.

Referring to Figure 3, handle 14 on housing 12 includes an on/off switch 24. Switch 24 is used to turn a light source such as lamp 26 on and off. Lamp 26, which may be mounted in housing 12 on shock absorbing supports, may be any of numerous lamps employed in such instruments, such as for example, a xenon lamp or other suitable source. Suitability for employment in forensic light source 10 is determined by the spectral emission of the lamp. In particular, lamps having sufficiently high spectral output within the desired output range of the instrument are suitable. The exact nature of the xenon lamp or any other suitable lamp is not a feature of this invention. The system also includes a fan 28 may be connected in parallel with lamp 26, whereby actuation of switch 24 results in turning both lamp 26 on and turning fan 28 on, thus providing for the cooling of the unit during use. Fan 28 is mounted adjacent to a port 30 for the circulation of air on the rear of the unit as illustrated in Figure 4. Port 30 may be a simple circular hole and may be covered by a grille 32 made of wire. Referring back to Figure 3, because there must be a flow of air through the instrument, a set of vents 34 are provided near the opposite end of housing 12.

In connection with venting it is noted that switch 24 may be made to individually

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1 control fan 28 and light source 26. More particularly, if desired, it is also possible for
2 switch 24 to be a three way switch in which the first position has both the fan and the
3 light source off, in a second position sends power only to fan 28 and in a third position
4 sends power to fan 28 and light source 26. This allows the light source to be turned off
5 while still continuing cooling to occur thus preserving the life of the unit.

6

7 As illustrated in Figure 3, the optical system in forensic light source 10 further
8 comprises a reflector 36 position to couple light output from lamp 26 to focusing optics
9 38. Focusing optics 38 serve to concentrate light directly received from lamp 26 and
10 indirectly received from lamp 26 by a reflector 36 to the output of the system.

11

12 A pair of filter wheel 40 and 42 are positioned within a cap housing 44 (Figure 1).
13 Referring back to Figure 3 taken in conjunction with Figure 5, it is seen that the filter
14 wheels, such as filter wheel 40 each have a mounting hole 44 which allows them to be
15 mounted for rotation on a post 46 (Figure 6). More particularly, both wheels 40 and 42
16 are mounted on post 46 and maybe freely rotated to put one or two filters over the
17 output of focusing optics 38 and thus filter such output.

18

19 More particularly, light output from focusing optics 38 passes through a hole 48
20 (Figure 3) through front wall 50 and then through a filter and filter wheel 40 and a
21 filter and filter wheel 42, or if no filter is selected through holes in either or both wheels
22 40 and 42.

23

24 This may be better understood with reference to Figure 6 where one filter 52 in filter
25 wheel 40 is positioned in a manner coupled to receive the output of focusing optics 38.
26 Five filters namely filters 52, 54, 56, 58 and 60 in similar fashion wheel 42 has filters 62-
27 70 as illustrated in Figure 6.

28

1 There is an alphanumeric designation 72 associated with each of the filters. Each
 2 alphanumeric designation 72 such as designation 72 designates the wavelength of its
 3 corresponding filter which is radially opposite the location of the alpha numeric
 4 designation. For example, alphanumeric designation 72 is opposite filter 56 whereas
 5 alphanumeric designation 74 is located opposite to filter 54. Likewise, another
 6 alphanumeric designation 76 is located opposite filter 58 and corresponds to the
 7 characteristics of filter 58. In similar fashion alphanumeric designation 74 corresponds
 8 to the characteristics of filter 54. Other alphanumeric designations on the system are
 9 not illustrated but are positioned in similar analogous fashion.

10

11 In accordance with the preferred embodiment, the system, or more particularly, the
 12 filter wheels 40 and 42 have holes, such as hole 78 in wheel 40 which do not include
 13 any filter and merely pass all light in order to output an uncolored or "white" light
 14 output. Hole 78 is a simple hole, in contrast with holes 80 which support the filters.
 15 Holes 80 have a suitable shoulder which supports the filter and are closed by a retainer
 16 spring ring 82, a plurality of which are employed in the system, each associated with
 17 one of the holes 80 in filter wheels 40 and 42, as illustrated in Figure 5.

18

19 Each of the filter wheels includes a mounting hole 83 upon which filter wheels 40 and
 20 42 are mounted for rotation. The filter wheels are maintained in position after being
 21 mounted by a closure cap 84, as shown and positioned in Figure 2. Closure cap 84 is
 22 shown in perspective in Figure 7.

23

24 As can be seen in Figures 3 and 5, filter wheels 40 and 42 include a plurality of notches
 25 86. Notches 86 serve to provide positive stops so that the filter wheels click into place
 26 in one of six specified positions. See also Figure 6. Filter wheels 40 and 42 may be
 27 rotated to any desired position through the use of knurled serrations 88. In accordance
 28 with the preferred embodiment of the invention, the output of light source 26 is

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1 outputted at a fixed point on housing 12. When hole 78, which has no filter mounted
2 in it, is lined up with the output point, then the unfiltered output spectrum, of the
3 lamp will be output by the system.

4

5 This may be better understood with reference to Figure 6 where it can be seen that
6 filter 52 is overlapping the proper point for lamp 26. See also Figure 3.

7

8 In accordance with the preferred embodiment of the invention, positive engagement of
9 the wheel and maintenance of the position of the wheel at the desired preset points is
10 achieved through the use of a mechanism which mates with detense or notches 86. The
11 particular mechanism used in accordance with the present invention is a spring loaded
12 ball bearing. More particularly, as can be seen with reference to Figure 8 a block 90
13 includes a hole 92 into which a spring 94 is positioned. A ball bearing is then pressed
14 over spring 94 and into hole 92 and a filter wheel pressed over it to keep it in position.
15 As the filter wheel is rotated, the ball, not illustrated, is forced into one of the detense
16 or notches 86 resulting in holding the filter in the desired position. The result is
17 illustrated in Figure 9 where a ball 96 is shown in phantom lines.

18

19 In accordance with the present invention, ease of use and light weight is achieved by
20 separating the light unit from the power supply, whether it be a battery pack or an
21 electrical power supply operated by the mains. Such situations are illustrated in
22 Figures 10 and 11. Referring first to Figure 10, a battery powers the system and the
23 power supplied by a battery pack 98 is connected by a five or six foot length of cord
24 100 to the forensic power source 10. Thus the weight of the battery pack is not a
25 burden to the user, the battery pack being simply put down on the floor or a piece of
26 furniture during use of the inventive system 10.

27

28 It is advantageous that the inventive forensic light source 10 also be powered by house

1 current. In this case a power supply 102 is used and power supply 102 may be
2 connected by a length of line cord 104 to house current source 106, as illustrated in
3 Figure 11. Here again a length of electrical cable 108 perhaps six or eight feet long is
4 used to connect power supply 102 to the ruggedized forensic light source 10.

5
6 The separation of the power supply or the battery from the remainder of the system
7 also contributes to the ruggedized nature of the system. More particularly, because the
8 weight of the battery is not connected to the delicate bulb and filter assembly, when the
9 same is dropped the momentum of the system is minimal and the damage caused by
10 the impact is reduced, thus resulting in a more rugged, more hearty and more reliable
11 system under normal police use which may in fact involve substantial abuse.

12
13 In accordance with the present invention, filter wheel 40 has an open hole, which
14 passes all light, and a plurality of filters. The filters in filter wheel 40 have the
15 following characteristics: a bandpass filter with a center wavelength of 440 nm with a
16 relatively broad bandwidth in the range of 40 to 50 nm; a bandpass filter with a center
17 wavelength 490 nm with a relatively broad bandwidth in the range of 40 to 50 nm; a
18 bandpass filter with a center wavelength of 540 nm with a relatively broad bandwidth
19 in the range of 40 to 50 nm ; a bandpass filter with a center wavelength of 590 nm with
20 a relatively broad bandwidth in the range of 40 to 50 nm ; and a short pass filter with a
21 maximum pass wavelength of 540 nm (which functions as a crime scene scanning
22 filter). The 540 nm filter is known as a crime scene scanning filter because it is most
23 useful in searching over wide areas of a crime scene in order to identify areas for
24 inspection under light of various wavelengths. Of course, in accordance with the
25 present invention, it is also contemplated that a crime scene will be searched under
26 white light and under light of various wavelengths, particularly in those areas of the
27 crime scene likely to contain various types of the evidence. In addition, to the extent
28 that it is known that various specific types of evidence are most visible under the light

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1 of one wavelength or another, it is anticipated that in accordance with the invention
2 that area will be examined on the light of the applicable wavelength or wavelengths.

3

4 Filter wheel 42 also has an open hole, which passes all light, and filters with the
5 following characteristics: a bandpass filter with a center wavelength of 415 nm with a
6 relatively broad bandwidth in the range of 40 to 50 nm ; a bandpass filter with a center
7 wavelength of 465 nm with a relatively broad bandwidth in the range of 40 - 50 nm; a
8 bandpass filter with a center wavelength of 515 nm with a relatively broad bandwidth
9 in the range of 40 to 50 nm; a bandpass filter with a center wavelength of 565 nm with a
10 relatively broad bandwidth in the range of 40 to 50 nm ; and a bandpass filter with a
11 center wavelength of 615 nm with a relatively broad bandwidth in the range of 40 to 50
12 nm.

13

14 In accordance with yet another embodiment of the invention, it is contemplated that
15 the system will incorporate a third filter wheel which has a number of very narrow
16 band reject filters. These may be selected to reject wavelengths which excite certain
17 commonly occurring wavelengths which constitute noise and present the possibility of
18 overpowering wavelengths which one wishes to detect or photograph.

19

20 Any suitable filters may be used in accordance with the invention, including, filters
21 made by holographic processes, dielectric coating, glass plates coated with layers of
22 materials incorporating dyes, and so forth. While lamps of other power may be used,
23 it is anticipated that the inventive system 10 will be used with a 100 watt lamp.

24

25 It accordance with the invention, it is contemplated that it may be desired to vary the
26 optical characteristics of the light output by the system. The same is achieved to the
27 use of a lens 112 (Figure 12a), mounted in a turret 114, which is slidably mounted in a
28 tubular member 116 secured to cap 84. Turret 114 may be positioned in various

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1 positions as illustrated in 12a and 12b in solid and phantom lines. In particular, a
 2 screw 118 which passes through a slot 120 is used to hold turret 114 in position.
 3 Rotation of turret 114 causes turret 114 to move into or out of tubular member 116,
 4 thus varying the distance between lens 112 and the lamp, and focusing the light into
 5 beams having different characteristics. Once adjusted in the desired manner, turret 114
 6 is held in position by tightening screw 118 which mates with a tapered hole in turret
 7 114.

8
 9 When it is decided to use the inventive system, the power supply 102 or battery pack
 10 98 is put on a table or on the ground at the crime scene. If the power supply is used,
 11 the same is plugged into standard house current.

12
 13 An individual then grasps the light source using his hand 16, as illustrated Figure 2.
 14 The thumb 22 of hand 16 may be used to rotate filter wheel 40 or 42 to put a desired
 15 filter or no filter at all into the path of light output from lamp 26.

16
 17 The user uses light of different wavelengths to inspect the crime scene for materials
 18 which will only be revealed by light of a particular wavelength, or which will be
 19 revealed in a better and easier to identify fashion by light of a selected wavelength.

20
 21 Moreover, in accordance with the invention, it is contemplated that filters from both
 22 filter wheel 40 and 42 may be used simultaneously in order to have a more selective
 23 filtering of wavelengths of light output by lamp 26. For example, if a filter having a
 24 center bandwidth of 415 nm is used simultaneously with the filter having a center
 25 bandwidth of 440 nm of the other filter wheel, the resultant filtering will have a center
 26 wavelength of approximately 427.5 nm and a bandpass characteristic whose largest
 27 wavelength is the longest wavelength passed by the 415 nm filter and a shortest
 28 wavelength which is the smallest wavelength passed by the 440 nm filter. In this way,

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1 inventive system 10, though it incorporates only nine filters, will provide nine wide
2 bandwidth bandpass characteristics (using one of the filters in one of the filter wheels,
3 with the other filter wheels set for an open hole which passes light all wavelengths)
4 and eight narrow bandwidth bandpass characteristics (using combinations of relatively
5 proximate wavelengths from each of the two filter wheels).
6 The above configuration allows for the individual use of nine broadband filters (415
7 nm, 440 nm, 465 nm, 490 nm, 515 nm, 540 nm, 565 nm, 590 nm, 615 nm), a short pass
8 filter (crime scene scanning filter) and white light for searching the crime scene.
9 Additionally, with the configuration mentioned above, nine additional commercially
10 useful wavelength filtering functions with relatively narrow bandwidth (20 to 25 nm)
11 can be achieved. These narrow bandpass filtering capabilities at intermediate
12 wavelengths are especially useful for photography at a crime scene and in many
13 instances will provide improved contrast photographs. More specifically, using the
14 415 nm filter of filter wheel 40 and the 440 nm filter of filter wheel 42, one obtains a
15 resultant bandpass with a center wavelength of 427.5 nm; using the 440 nm filter of
16 filter wheel 42 and the 465 nm filter of filter wheel 40, one obtains a resultant bandpass
17 with a center wavelength of 452.5 nm; using the 465 nm filter of filter wheel 40 and the
18 490 nm filter of filter wheel 42, one obtains a resultant bandpass with a center
19 wavelength of 477.5 nm; using the 490 nm filter of filter wheel 42 and the 515 nm filter
20 of filter wheel 40, one obtains a resultant bandpass with a center wavelength of 502.5
21 nm; using the 515 nm filter of filter wheel 40 and the 540 nm filter of filter wheel 42,
22 one obtains a resultant bandpass with a center wavelength of 527.5 nm; using the 540
23 nm filter of filter wheel 42 and the 565 nm filter of filter wheel 40, one obtains a
24 resultant bandpass with a center wavelength of 552.5 nm; using the 565 nm filter of
25 filter wheel 40 and the 590 nm filter of filter wheel 42, one obtains a resultant bandpass
26 with a center wavelength of 577.5 nm; and using the 590 nm filter of filter wheel 42 and
27 the 615 nm filter of filter wheel 40, one obtains a resultant bandpass with a center
28 wavelength of 602.5 nm.

1 Further, using the 590 nm filter of filter wheel 40 and the crime scene scanning filter of
2 filter wheel 42, one obtains an asymmetrical filtering characteristic that represents the
3 juxtaposition of the two characteristics of the two filters. There is a sharp decline in
4 fluorescence transmission at the high-end while excitation reflection is blocked. This is
5 useful for highly reflective surfaces, such as aluminum.

6
7 It is further contemplated that three or more filter wheels may be used in accordance
8 with the present invention. The same may be used to provide an increased number of
9 broad band filters. The use of three or more filter wheels will also provide greater
10 flexibility in making combinations of different filters. These filters may also be used
11 together to achieve an increasingly narrow bandpass filtering. In addition, the use of
12 three or more filter wheels will allow selection of bandpass widths. For example, it
13 may be desired in some cases to combine a 590 nm filter with a 565 nm filter having a
14 first bandwidth while at other times to combine the same 590 nm filter with a 565 nm
15 filter having a second bandwidth, in order to bare the resultant bandwidth. This can
16 be accommodated through the use of additional filter wheels, or filter wheels with
17 greater numbers of filters on them.

18
19 In an alternative embodiment, filter wheel 140 has an open hole, which passes all light,
20 and a plurality of filters. The filters in filter wheel 140 have the following
21 characteristics: a bandpass filter with a center wavelength of 415 nm with a broad
22 bandwidth in the range of 40 to 50 nm; a bandpass filter with a center wavelength 440
23 nm with a broad bandwidth in the range of 40 to 50 nm; a bandpass filter with a center
24 wavelength of 465 nm with a broad bandwidth in the range of 40 to 50 nm ; a bandpass
25 filter with a center wavelength of 490 nm with a broad bandwidth in the range of 40 to
26 50 nm; and a bandpass filter with a center wavelength of 515 nm with a broad
27 bandwidth in the range of 40 to 50 nm. In accordance with this embodiment of the
28 invention, filter wheel 142 also has an open hole, which passes all light, and filters with

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1 the following characteristics: a bandpass filter with a center wavelength of 540 nm with
2 a broad bandwidth in the range of 40 to 50 nm; a bandpass filter with a center
3 wavelength of 565 nm with a broad bandwidth in the range of 40 to 50 nm; a bandpass
4 filter with a center wavelength of 590 nm with a broad bandwidth in the range of 40 to
5 50 nm; a bandpass filter with a center wavelength of 615 nm with a broad bandwidth
6 in the range of 40 to 50 nm; and a short pass filter with a maximum pass wavelength of
7 540 nm (crime scene scanning filter).

8
9 While an illustrative embodiment of the invention has been described, it is, of course,
10 understood that various modifications of the invention will be obvious to those of
11 ordinary skill in the art. Such modifications are within the spirit and scope of the
12 invention which is limited and defined only by the appended claims.

13
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